This is called the *Langlands decomposition* of $\mathbf{q}_1$ **[GaVa, Knap2, Wall2]**. It is easy to see that $\mathbf{m}_1$ is a reductive Lie subalgebra of $\mathbf{g}$. We can define a corresponding subgroup M_1 of G as follows. The group $Q_1 \cap \theta(Q_1)$ has a Cartan decomposition (cf. (A.2.3.1))

$$Q_1 \cap \theta(Q_1) = (Q_1 \cap \theta(Q_1) \cap K) \exp(\mathbf{q}_1 \cap \mathbf{p}).$$

Set

$$M_1 = (Q_1 \cap \theta(Q_1) \cap K) \exp(\mathbf{m}_1 \cap \mathbf{p}). \tag{A.2.4.5}$$

Then the Cartan decomposition plus decompositions (A.2.4.4) tell us that

$$P_1 = M_1 A_1 N_1^+ \tag{A.2.4.6}$$

in the strong sense that the map from $M_1 \times A_1 \times N_1^+$ defined by multiplication to P_1 is a diffeomorphisn. The factorization (A.2.4.6) is called the *Langlands decomposition* of P_1.

The procedure sketched above constructs 2^r, where $r = \#(\mathscr{F})$, parabolic subgroups of G containing P_0. These are all possible parabolics containing P_0. To show this requires a more detailed study of root systems than we wish to give here. Instead we will finish as we started, by looking at GL_n. We will sketch how to see that possibilities for subgroups of GL_n containing the Borel subgroup of upper triangular matrices are the groups of block upper triangular matrices defined by various partial flags (cf. §1.4). Consider the basis $\{E_{jk}\}_{j,k=1}^n$ of standard matrix units for $\mathbf{gl}_n$. These satisfy the commutation relations

$$[E_{jk}, E_{lm}] = \delta_{kl} E_{jm} - \delta_{jm} E_{lk}.$$

The upper triangular matrices $\mathbf{b}^+$ are the span of the E_{jk} with $j \leq k$. Suppose we add to this another element $x = \sum c_{lm} E_{lm}$. Since the E_{lm}'s are eigenvectors for the $\operatorname{ad} E_{jj}$, with distinct eigenvalues, we find that if $c_{lm} \neq 0$, then E_{lm} is in the algebra generated by $\mathbf{b}^+$ and x. So take $x = E_{lm}$ for some $l > m$. Taking commutators with E_{jl}, $j \leq l$, shows us E_{jm} belongs to the algebra generated by E_{lm} and $\mathbf{b}^+$. Similarly, we must have E_{lk}, $k \geq m$, in this algebra. Repeating this process, we find that all E_{jk}, $j \leq l$, $k \geq m$, are in the algebra. These span the whole block to the upper right of E_{lm}. Next suppose we have two elements E_{lm}, E_{rs} which generate overlapping blocks, in the sense that $m < s \leq l < r$. Then from the argument above, we can find E_{rl} in the algebra generated by $\mathbf{b}^+$ and E_{rs}. Hence $[E_{rl}, E_{lm}] = E_{rm}$ is in our algebra, and therefore so is the smallest diagonal block containing *both* E_{lm} and E_{rs}. Thus we get the general parabolic containing $\mathbf{b}^+$ by adding *disjoint* diagonal blocks. We remark that the calculations sketched above are similar to those used in the context of general root systems.

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DEPARTMENT OF MATHEMATICS, YALE UNIVERSITY, NEW HAVEN, CONNECTICUT 06520